Microshield and MCNP5 Modeling of Natural Uranium Ore Mined Using Ablation Technology

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TABLES

1. INTRODUCTION

On the behalf of SHB Inc. (SHB), Environmental Restoration Group Incorporated (ERG) has prepared this report describing computer modeling used to estimate the exposure rates posed by ionizing radiation emitted from mineralized material obtained using ablation technology from an underground uranium mine. Ablation technology is used to increase the average grade of the ore. Microshield (Grove Software, 2014) was used to as the primary modeling code for this effort. In addition, the Monte Carlo N-Particle 5 (MCNP5) v. 1.60 code and data libraries (LANL, 2011) were used to validate the Microshield results and help quantify the conservative protocols inherent to Microshield, as well as those input by ERG.

2. METHODS AND MODEL INPUTS

Each source was modeled separately and the exposure rates summed. This method did not account for shielding from components or equipment, other than self-shielding of the component being modeled.

The model inputs include components, sources, and receptors, as described below.

2.1 Components

Fourteen components were modeled. Dimensions of each component were provided by SHB in the form "length by width by height", suggesting cuboidal geometries. To facilitate the modelling effort, each was modeled as a cylinder of varying radius and length based on its dimensions, in both MCNP5 and Microshield. A radius for each cylindrically modeled component was found by dividing the volume calculated using the provided dimensions and dividing by the length of the component which was then divided by pi and the square root taken. Each component was modeled as either uncovered ore or a steel cylinder with ore in its interior.

Table 1 lists the components and their pertinent geometry; and shielding materials and thicknesses.

Table 1: Components Modeled

Component	Length (cm)	Radius (cm)	Shielding Material	Shielding Thickness (mm)
Cone Crusher	235	116.5	Steel	50
Conveyor # 1	304		None	N/A
ROM Hopper	244	137.7	Steel	4.7625
Conveyor # 2	304		None	N/A
Mix Tank	259	123.0	Steel	9.525
Ablation Units (3)	777	123.0	Steel	4.7625
Orival Filters (3)	165	52.1	Steel	4.7625
Centrifuge (3)	165	52.1	Steel	4.7625
Filter Press	1219	97.9	Steel	4.7625
Filter Press #2	1219	97.9	Steel	4.7625
Super Sack Filling Station	366	163.2	Steel	4.7625
Truck to surface	1066	123.8	Steel	9.525
Storage pad for waste rock	305	343.5	None	N/A
Waste Truck to underground dump	1066	123.8	Steel	9.525

Notes:
cm = centimeter
mm = millimeter

2.2 Sources

Each component in Table 1 was modeled as a source of radiation with radioactive material contained in its interior or as the component itself (e.g., the waste trench and conveyors). Important characteristics of these sources included the mass, density, volume, percent solids, and average grade of uranium.

Important physical characteristics of the sources are presented in Table 2 and were provided by SHB. The mass of the material was given as a dry equivalent mass. However, in many cases, the radioactive material was modeled as a slurry: a mixture of rock and water. Therefore, the mass of the water was added to the dry equivalent mass. To model the slurry, the density of the material was changed from the density of pure rock (2 g/cm^3), to that of rock and water. This lowered the density of the mixture to a greater extent for materials with a smaller percentage of solids. The additional water was also incorporated into the slurry in the Microshield and MCNP5 inputs as a larger incorporation of hydrogen and oxygen in the slurry's elemental composition. Steel shells were assumed to have a density of 8 g/cm^3 and were modeled as stainless steel type 304L. All material elemental compositions were modelled on data from "Compendium of Material Composition Data for Radiation Transport Modelling" (PNNL, 2011).

To facilitate the modelling effort, the interior of each component was assumed to be filled with radioactive material (slurry or ore); i.e. the material was distributed evenly in its volume, even if it occupied only a portion of the volume. In this case, the density provided by SHB was modified accordingly. However, the mass of the material was unchanged. The modeled density of the material was calculated as the material mass divided by the volume of the interior of the component (far right column of Table 2). This is a conservative assumption, which allows for less mass to contribute to the attenuation of gamma radiation between the source and receptor. Based on the MCNP5 validation in Section 3.1, this assumption could be quite conservative and result in overestimates of exposure rates by approximately 40%.

Table 2 lists by component 1) equivalent dry mass of ore or slurry in the component 2) the average grade of uranium and activity per cubic centimeter for U-238 and U-235, including their decay progeny; 2) its interior volume; and dry equivalent mass and density of the ore or slurry; and 3) the total density (density of the component contents including void space). Emission rates for photons were taken from Microshield data libraries for the Microshield calculations, while photon emission rates for MCNP5 were taken from a program published by Lawrence Livermore National Laboratory (LLNL, 2015).

Table 2: Source Information

Component	Dry Equivalent Mass of Ore or Slurry (kg)	Average U grade of solids (% U)	Interior Volume of Component (cubic centimeters [cc])	U-238 + D (Bq/cc)	U-235 + D (Bq/cc)	Density of Ore or Slurry (g/cc)	Total Density of Contents Including Void Space (g/cc)
Cone Crusher	45	0.25	10024395	0.13	0.01	2.00	0.004
Conveyor # 1	270	0.25	135000	60.00	2.70	2.00	2.000
ROM Hopper	21000	0.25	14526784	43.37	1.95	2.00	1.446
Conveyor # 2	270	0.25	135000	60.00	2.70	2.00	2.000
Mix Tank	340	0.25	12302241	0.83	0.04	1.11	0.138
Ablation Units (3)	1020	0.25	36906723	0.83	0.04	1.11	0.138
Orival Filters (3)	24	0.75	1404480	1.54	0.07	1.05	0.171
Centrifuge (3)	12	1	1404480	1.03	0.05	1.03	0.171
Filter Press	2270	1	36687024	7.42	0.33	1.60	0.082
Filter Press #2	2270	1	36687024	7.42	0.33	1.60	0.082
Super Sack Filling Station	4536	1	30608946	17.78	0.80	1.60	0.198
ABT Product Truck to Surface (Truck #1)	9072	1	51289524	21.23	0.95	1.60	0.236
Storage pad for waste rock	160000	0.01	113025680	1.70	0.08	1.74	1.665
Waste Rock Truck to Underground Dump (Truck #2)	9072	0.01	51289524	0.21	0.01	1.74	0.208

Notes:
Bq/cc = Bequerels per cubic centimeter
cc = cubic centimeter
g/cc = grams per cubic centimeter
kg = kilograms

2.3 Receptors

Twenty-four receptors were modeled at the center points of a 6.1 meter (m) square grid (the given dimensions of the room were 24.4 m by 36.6 m). Some receptors were offset from the center points if they were co-located with a component. Figure 1 shows the receptor locations.

2.4 Microshield Results

Results in units of exposure rate (milliRoentgen per hour (mR/hr)) were plotted and kriged to produce Figure 1, a map depicting the exposure rates (at receptor locations and interpolated) that are predicted for the ablation technology room. Kriging interpolated exposure rates between the 24 receptor points. The kriging did not account for the components, as is evidenced by the asymmetry of exposure rates around components as the kriging created an estimated exposure rate for each point on the map based on the 24 explicit receptor locations. Table 3 lists the exposure rates predicted for each of the 24 receptors attributable to each source and total exposure rates by receptor.

Table 3: Microshield Results

Component	Receptor Location Exposure Rate (mR/hr)											
	1	2	3	4	5	6	7	8	9	10	11	12
Cone Crusher	1.88E-05	1.79E-05	1.12E-05	6.75E-06	4.78E-06	4.06E-06	3.75E-05	3.54E-05	1.64E-05	9.92E-06	7.70E-06	6.44E-06
Conveyor 1	5.27E-05	5.48E-05	5.17E-05	4.06E-05	2.87E-05	2.15E-05	1.06E-04	1.18E-04	9.99E-05	6.32E-05	3.75E-05	2.55E-05
ROM Hopper	3.46E-03	3.65E-03	3.62E-03	3.31E-03	2.55E-03	1.99E-03	6.57E-03	7.85E-03	7.75E-03	5.96E-03	3.78E-03	2.61E-03
Conveyer 2	4.47E-05	5.42E-05	5.63E-05	5.26E-05	4.06E-05	3.09E-05	7.34E-05	1.11E-04	1.22E-04	1.01E-04	6.24E-05	4.13E-05
Mix Tank	2.21E-04	2.98E-04	3.67E-04	3.42E-04	2.71E-04	2.13E-04	3.36E-04	5.46E-04	7.80E-04	6.96E-04	4.63E-04	3.16E-04
Ablation Tanks	5.64E-04	8.34E-04	1.15E-03	1.37E-03	1.31E-03	1.11E-03	6.88E-04	1.22E-03	2.09E-03	2.90E-03	2.66E-03	1.94E-03
Orival Filters	3.47E-05	4.95E-05	7.03E-05	9.36E-05	1.10E-04	1.05E-04	4.16E-05	6.53E-05	1.08E-04	1.76E-04	2.34E-04	2.20E-04
Centrifuges	2.03E-05	2.89E-05	4.14E-05	5.70E-05	6.98E-05	7.37E-05	2.38E-05	3.65E-05	5.95E-05	9.91E-05	1.46E-04	1.58E-04
Filter Press 1	6.45E-03	1.06E-02	1.66E-02	2.23E-02	2.25E-02	1.86E-02	6.89E-03	1.44E-02	3.21E-02	5.72E-02	5.83E-02	3.97E-02
Filter Press 2	6.98E-03	1.32E-02	2.52E-02	3.95E-02	3.98E-02	2.94E-02	5.81E-03	1.43E-02	5.03E-02	1.49E-01	1.53E-01	7.54E-02
Sack Filling Station	1.87E-02	3.03E-02	3.96E-02	3.16E-02	1.96E-02	1.31E-02	2.85E-02	7.10E-02	1.48E-01	7.81E-02	3.09E-02	1.72E-02
Truck # 1	6.06E-02	6.52E-02	4.30E-02	2.25E-02	1.15E-02	7.03E-03	1.73E-01	2.02E-01	8.09E-02	2.51E-02	1.02E-02	5.91E-03
Truck # 2	8.91E-05	1.95E-04	6.88E-04	1.17E-02	1.55E-02	3.88E-03	8.61E-05	1.88E-04	5.12E-04	1.40E-03	1.82E-03	1.12E-03
Waste Trench	4.14E-04	6.15E-04	9.85E-04	1.80E-03	4.46E-03	2.02E-02	4.53E-04	6.94E-04	1.16E-03	2.24E-03	5.58E-03	2.09E-02
Total Exposure Rate	9.76E-02	1.25E-01	1.31E-01	1.35E-01	1.18E-01	9.58E-02	2.22E-01	3.13E-01	3.24E-01	3.23E-01	2.67E-01	1.65E-01

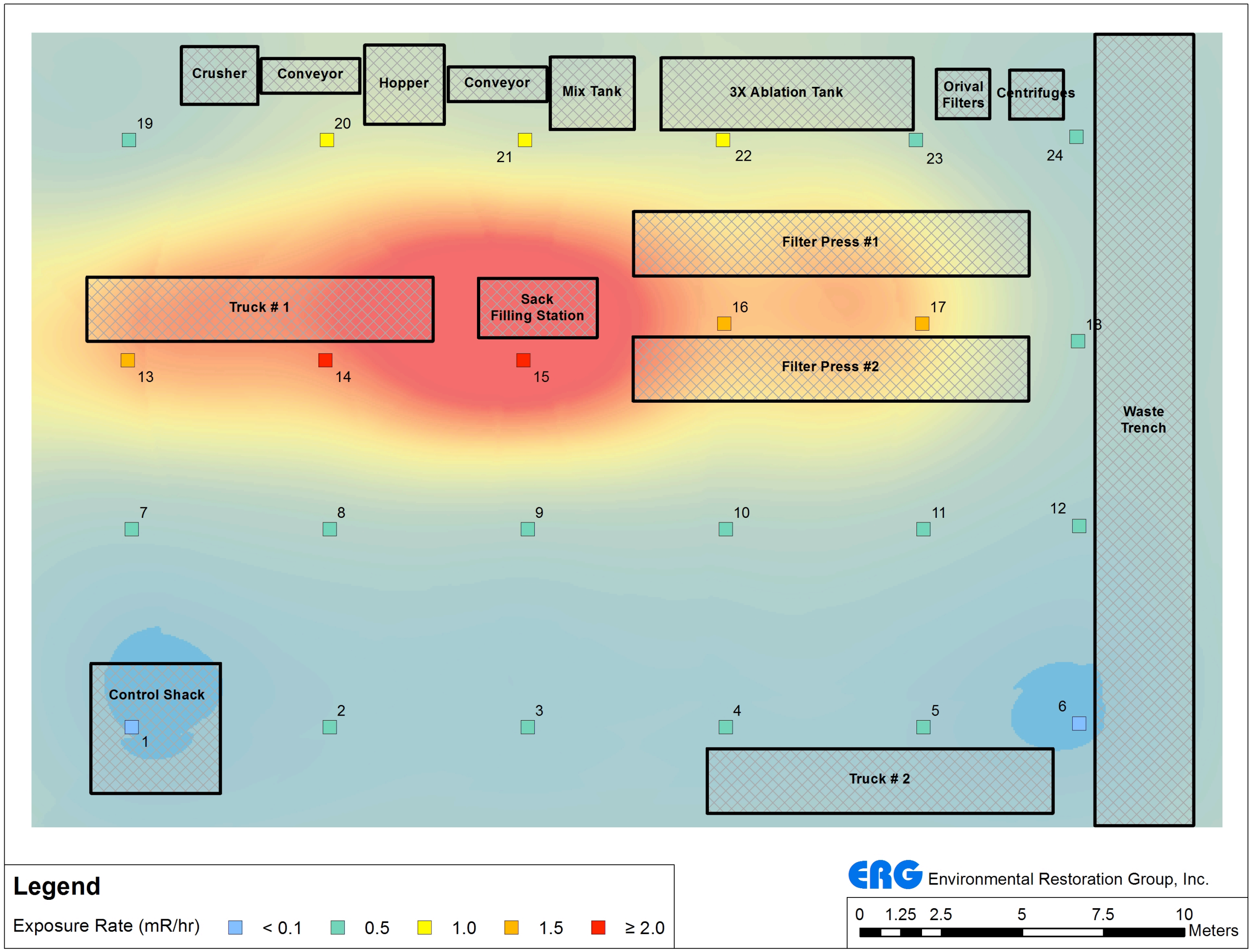
Notes:
mR/hr = milliRoentgens per hour
[?] The exposure rate at receptor location 15 was originally found to be 2.57 mR/hr and was located 3 cm from the sack filling station surface. This contribution was reran at one meter, which resulted in the tabulated value.

Table 3: Microshield Results (Concluded)

Component	Receptor Location Exposure Rate (mR/hr)											
	13	14	15 [?]	16	17	18	19	20	21	22	23	24
Cone Crusher	8.24E-05	7.55E-05	2.62E-05	2.21E-05	1.44E-05	1.02E-05	4.50E-04	4.44E-04	1.09E-04	4.19E-05	2.19E-05	1.43E-05
Conveyor 1	2.25E-04	3.13E-04	2.01E-04	9.30E-05	4.36E-05	2.70E-05	5.65E-04	6.06E-03	3.92E-04	8.99E-05	3.78E-05	2.22E-05
ROM Hopper	1.20E-02	2.06E-02	1.96E-02	1.13E-02	4.79E-03	3.08E-03	2.25E-02	2.11E-01	1.12E-01	1.65E-02	6.02E-03	3.37E-03
Conveyer 2	1.07E-04	2.44E-04	3.31E-04	2.28E-04	8.95E-05	4.84E-05	1.15E-04	6.60E-04	7.03E-03	3.50E-04	8.54E-05	4.10E-05
Mix Tank	4.67E-04	9.77E-04	1.99E-03	2.04E-03	8.44E-04	4.52E-04	7.06E-04	2.19E-03	2.13E-02	8.56E-03	1.46E-03	6.46E-04
Ablation Tanks	6.93E-04	1.51E-03	3.71E-03	9.59E-03	7.75E-03	3.44E-03	6.27E-04	1.45E-03	6.09E-03	1.12E-01	5.22E-02	4.69E-03
Orival Filters	4.62E-05	7.74E-05	1.48E-04	3.84E-04	8.29E-04	5.94E-04	5.26E-05	9.20E-05	4.95E-04	6.44E-04	1.04E-02	2.74E-03
Centrifuges	2.61E-05	4.19E-05	7.62E-05	1.80E-04	4.51E-04	4.79E-04	2.95E-05	4.90E-05	9.53E-05	2.53E-04	1.64E-03	8.84E-03
Filter Press 1	5.34E-03	1.30E-02	5.36E-02	3.79E-01	3.90E-01	1.04E-01	5.32E-03	1.27E-02	5.53E-02	2.67E-01	2.80E-01	1.02E-01
Filter Press 2	6.01E-03	1.43E-02	7.13E-02	7.21E-01	7.32E-01	1.77E-01	6.55E-03	1.48E-02	3.83E-02	8.00E-02	8.33E-02	4.98E-02
Sack Filling Station [?]	3.70E-02	1.48E-01	1.01E+00 [?]	2.15E-01	4.33E-02	2.07E-02	3.07E-02	8.88E-02	2.61E-01	1.04E-01	3.53E-02	1.81E-02
Truck # 1	1.39E+00	1.51E+00	1.63E-01	2.92E-02	1.10E-02	6.39E-03	2.50E-01	3.07E-01	9.51E-02	2.47E-02	9.99E-03	5.83E-03
Truck # 2	9.59E-05	1.83E-04	3.57E-04	5.37E-04	6.13E-04	5.28E-04	9.08E-05	1.43E-04	2.15E-04	2.89E-04	3.11E-04	2.74E-04
Waste Trench	4.53E-04	6.92E-04	1.16E-03	2.22E-03	5.52E-03	2.04E-02	4.14E-04	6.14E-04	9.85E-04	1.80E-03	4.32E-03	1.94E-02
Total Exposure Rate	1.46E+00	1.71E+00	1.33E+00	1.37E+00	1.20E+00	3.38E-01	3.18E-01	6.46E-01	5.98E-01	6.16E-01	4.85E-01	2.16E-01

Notes:
mR/hr = milliRoentgens per hour
[?] The exposure rate at receptor location 15 was originally found to be 2.57 mR/hr and was located 3 cm from the sack filling station surface. This contribution was reran at one meter, which resulted in the tabulated value.

Figure 1: Mapped Exposure Rates (mR/hr)



3. DISCUSSION OF RESULTS

Modeled exposure rates in the room are all greater than 0.09 mR/hr. The largest sources of exposure in the room are the sack filling station and Truck #1. The summed "Total Exposure Rates" in Table 3 are affected largely by the presence of Truck # 1 and sack filling station. For example, if the truck is empty (which it will be at some times) the exposure rate at the "Control Shack" (Location 1) lowers from 0.09 to 0.03 mR/hr.

The exposure rates can be translated to dose rates (approximated) in millirem per hour (mrem/hr) by being multiplied by 0.877 rad absorbed dose in air per Roentgen and multiplied by the ratio of the mass energy absorption coefficient for tissue over the mass energy absorption for air (a ratio of approximately 1.1).

The Microshield and MCNP5 outputs are available upon request.

3.1 Validation with MCNP5 and Sources of Error

The results obtained using Microshield were validated by comparing them to those obtained using MCNP5. The filter press was modeled, for example, using the parameters described in Section 2.0, using both models. The point of interest was 1 m from the center of the filter press, which was modeled as a cylinder. The MCNP5-derived exposure rate was 0.452 mR/hr. The Microshield- derived exposure rate was 0.54 mR/hr; a difference of 16%. The difference may be attributed to 1) Microshield buildup factors, which are based on beam geometries that are monodirectional, not scattered (i.e., isotropic radiation) or 2) the geometry of the model. Attachment 1 includes the results of the Microshield modelling for this scenario.

To compare the effect of the slurry volume and density, one of the filter presses was modeled with a layer of slurry inside the cylinder at the calculated density of 1.6 g/cc, instead of filling the volume of the cylinder and lowering the density of the slurry to the modeled 0.0825 g/cc. Both instances were modeled and the result for the layer of slurry at a density of 1.6 g/cc was 42.5% lower than the same model with the slurry mass distributed throughout the filter press volume.

The predicted exposure rates between locations vary throughout the room due to component proximity and ore grade. Receptor Location 15, for instance, is 3 cm from the surface of the "sack filling station", which contains an ore grade of one percent. A more reasonable approach than gridding, i.e. selecting locations based on where individuals may spend a majority of their time, may be more useful to assess doses to workers.

4. CONCLUSION

Exposure rates that were predicted for the room containing the ablation technology were modeled using Microshield. These exposure rates are conservative and these conservatisms have been approximated.

5. REFERENCES

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Attachment 1:

Microshield Filter Press Output

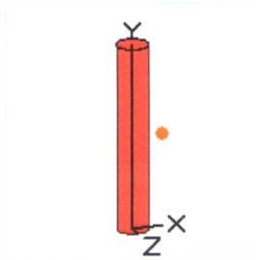
MicroShield 9.07
ERG (9.07-0000)

Date	By	Checked

Filename	Run Date	Run Time	Duration
FilterPress_Validation.msd	February 17, 2016	4:49:00 PM	00:00:00

Project Info	
Case Title	Case 1
Description	Case 1
Geometry	7 - Cylinder Volume - Side Shields

Source Dimensions	
Height	1.2e+3 cm (39 ft 11.9 in)
Radius	97.4 cm (3 ft 2.3 in)



Dose Points

A	X	Y	Z
#1	197.9 cm (6 ft 5.9 in)	609.5 cm (19 ft 12.0 in)	0.0 cm (0 in)

Shields

Shield N	Dimension	Material	Density
Source	3.63e+07 cm³	Slurry(75%)	0.0825
Transition		Air	0.0009
Air Gap		Air	0.00122
Wall Clad	.476 cm	Steel	8
Top Clad	.476 cm	Steel	8

Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Excluded
Library: ICRP-107

Nuclide	Ci	Bq	μCi/cm³	Bq/cm³
Ac-227	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
At-218	1.5154e-006	5.6070e+004	4.1712e-008	1.5433e-003
At-219	2.8800e-010	1.0656e+001	7.9272e-012	2.9331e-007
Bi-210	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Bi-211	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
Bi-214	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Bi-215	2.7936e-010	1.0336e+001	7.6894e-012	2.8451e-007
Fr-223	4.8000e-006	1.7760e+005	1.3212e-007	4.8884e-003
Hg-206	1.4396e-010	5.3267e+000	3.9626e-012	1.4662e-007
Pa-231	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
Pa-234	1.2122e-005	4.4853e+005	3.3367e-007	1.2346e-002
Pa-234m	7.5765e-003	2.8033e+008	2.0854e-004	7.7161e+000
Pb-210	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Pb-211	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
Pb-214	7.5755e-003	2.8029e+008	2.0852e-004	7.7151e+000
Po-210	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Po-211	9.6000e-007	3.5520e+004	2.6424e-008	9.7769e-004
Po-214	7.5754e-003	2.8029e+008	2.0851e-004	7.7150e+000

file:///C:/Program%20Files%20(x86)/MicroShield%209/Examples/CaseFiles/HTML/Filter... 2/17/2016

Po-215	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
Po-218	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Ra-223	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
Ra-226	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Rn-218	1.5154e-009	5.6070e+001	4.1712e-011	1.5433e-006
Rn-219	3.4783e-004	1.2870e+007	9.5739e-006	3.5424e-001
Rn-222	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Th-227	3.4303e-004	1.2692e+007	9.4418e-006	3.4935e-001
Th-230	7.5770e-003	2.8035e+008	2.0856e-004	7.7167e+000
Th-231	3.4781e-004	1.2869e+007	9.5735e-006	3.5422e-001
Th-234	7.5765e-003	2.8033e+008	2.0854e-004	7.7161e+000
Tl-206	1.0146e-008	3.7539e+002	2.7926e-010	1.0333e-005
Tl-207	3.4687e-004	1.2834e+007	9.5475e-006	3.5326e-001
Tl-210	1.5912e-006	5.8874e+004	4.3797e-008	1.6205e-003
U-234	7.5769e-003	2.8035e+008	2.0855e-004	7.7165e+000
U-235	3.4781e-004	1.2869e+007	9.5735e-006	3.5422e-001
U-238	7.5765e-003	2.8033e+008	2.0854e-004	7.7161e+000

Buildup: The material reference is Source

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	10

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup	Absorbed Dose Rate mrad/hr No Buildup	Absorbed Dose Rate mrad/hr With Buildup	Absorbed Dose Rate mGy/hr No Buildup	Absorbed Dose Rate mGy/hr With Buildup
0.015	6.829e+07	3.106e-96	8.045e-27	2.664e-97	6.901e-28	2.326e-97	6.024e-28	2.326e-99	6.024e-30
0.02	1.364e+07	2.268e-45	2.537e-27	7.857e-47	8.789e-29	6.859e-47	7.673e-29	6.859e-49	7.673e-31
0.03	3.227e+06	4.087e-17	6.717e-17	4.051e-19	6.657e-19	3.536e-19	5.812e-19	3.536e-21	5.812e-21
0.04	1.122e+05	8.657e-11	1.994e-10	3.829e-13	8.820e-13	3.342e-13	7.700e-13	3.342e-15	7.700e-15
0.05	1.705e+07	1.794e-05	5.633e-05	4.779e-08	1.501e-07	4.172e-08	1.310e-07	4.172e-10	1.310e-09
0.06	1.489e+07	5.495e-04	2.154e-03	1.091e-06	4.277e-06	9.528e-07	3.734e-06	9.528e-09	3.734e-08
0.08	7.477e+07	7.009e-02	3.287e-01	1.109e-04	5.202e-04	9.683e-05	4.541e-04	9.683e-07	4.541e-06
0.1	2.741e+07	1.035e-01	4.980e-01	1.584e-04	7.618e-04	1.383e-04	6.651e-04	1.383e-06	6.651e-06
0.15	3.848e+06	5.961e-02	2.518e-01	9.817e-05	4.146e-04	8.570e-05	3.620e-04	8.570e-07	3.620e-06
0.2	4.182e+07	1.207e+00	4.477e+00	2.131e-03	7.902e-03	1.860e-03	6.898e-03	1.860e-05	6.898e-05
0.3	6.770e+07	3.918e+00	1.197e+01	7.431e-03	2.271e-02	6.487e-03	1.983e-02	6.487e-05	1.983e-04
0.4	1.118e+08	1.010e+01	2.700e+01	1.968e-02	5.261e-02	1.718e-02	4.593e-02	1.718e-04	4.593e-04
0.5	6.437e+06	8.110e-01	1.952e+00	1.592e-03	3.831e-03	1.390e-03	3.344e-03	1.390e-05	3.344e-05
0.6	1.363e+08	2.243e+01	4.968e+01	4.378e-02	9.697e-02	3.822e-02	8.465e-02	3.822e-04	8.465e-04
0.8	3.009e+07	7.502e+00	1.475e+01	1.427e-02	2.806e-02	1.246e-02	2.450e-02	1.246e-04	2.450e-04
1.0	8.158e+07	2.793e+01	5.033e+01	5.148e-02	9.277e-02	4.494e-02	8.099e-02	4.494e-04	8.099e-04
1.5	5.127e+07	3.078e+01	4.843e+01	5.179e-02	8.148e-02	4.521e-02	7.114e-02	4.521e-04	7.114e-04
2.0	7.587e+07	6.668e+01	9.772e+01	1.031e-01	1.511e-01	9.002e-02	1.319e-01	9.002e-04	1.319e-03
3.0	4.473e+05	6.548e-01	8.840e-01	8.884e-04	1.199e-03	7.755e-04	1.047e-03	7.755e-06	1.047e-05
4.0	3.739e+01	7.713e-05	9.926e-05	9.542e-08	1.228e-07	8.330e-08	1.072e-07	8.330e-10	1.072e-09
5.0	9.932e+00	2.647e-05	3.302e-05	3.034e-08	3.785e-08	2.649e-08	3.304e-08	2.649e-10	3.304e-10

6.0	1.882e+00	6.142e-06	7.498e-06	6.669e-09	8.142e-09	5.822e-09	7.108e-09	5.822e-11	7.108e-11
8.0	2.112e-01	9.391e-07	1.107e-06	9.439e-10	1.113e-09	8.241e-10	9.714e-10	8.241e-12	9.714e-12
10.0	1.821e-02	1.021e-07	1.176e-07	9.723e-11	1.120e-10	8.488e-11	9.776e-11	8.488e-13	9.776e-13
Totals	**8.266e+08**	**1.722e+02**	**3.083e+02**	**2.965e-01**	**5.403e-01**	**2.589e-01**	**4.717e-01**	**2.589e-03**	**4.717e-03**